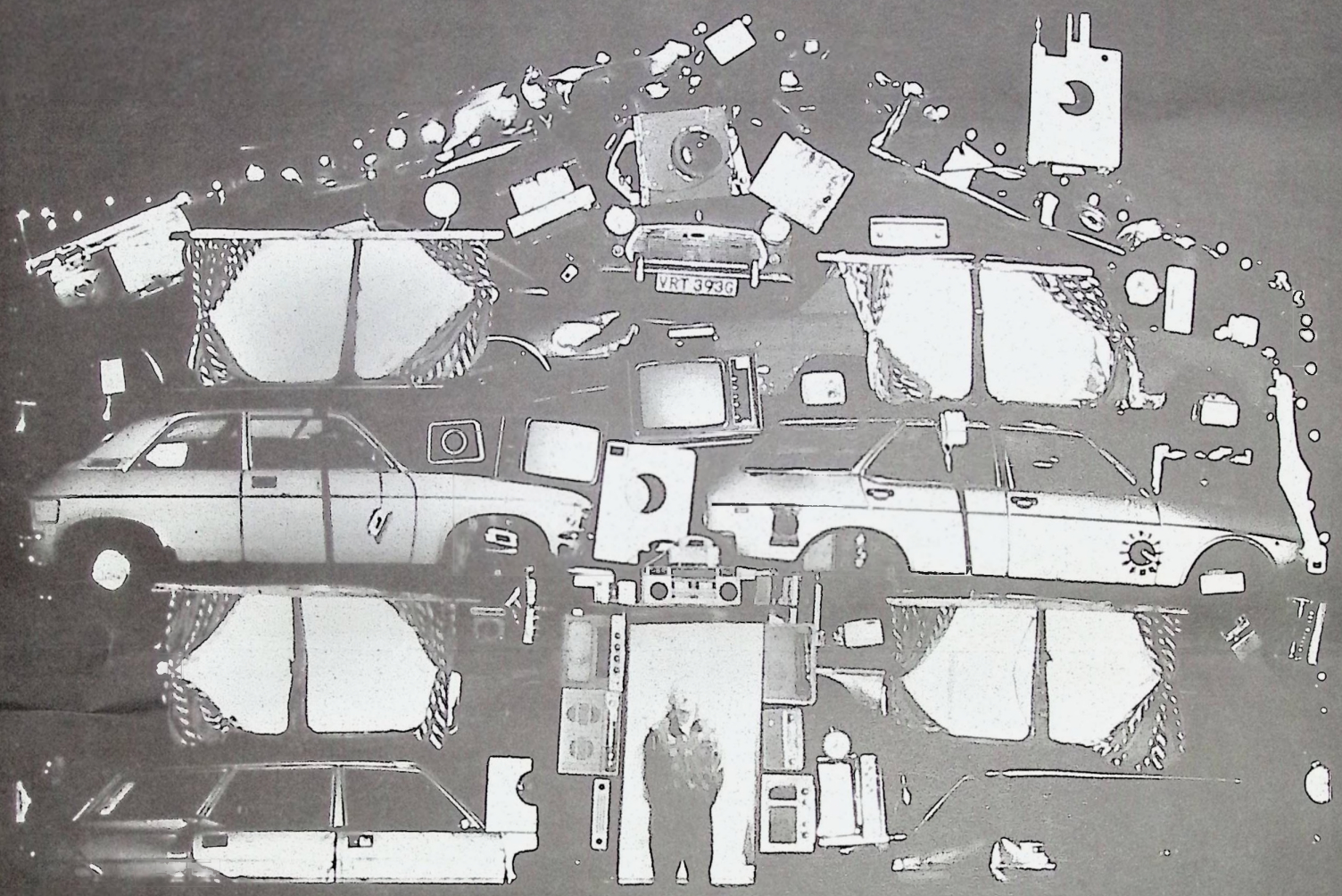
THE SECRET LIFE OF MACHINES II



IT'S A TRIUMPH OF MODERN TECHNOLOGY THAT PEOPLE CAN NOW USE THE MACHINES AROUND THEM WITHOUT ANY IDEA OF WHAT'S GOING ON INSIDE. UNTIL 100 YEARS AGO ANYBODY WHO HAD A MACHINE NEEDED TO KNOW EXACTLY HOW IT WORKED IN ORDER TO USE IT AND KEEP IT GOING. HOWEVER, THIS MODERN IGNORANCE DOES TEND TO LEAVE SLIGHTLY RESENTFUL FEELINGS OF BEING 'OUT OF CONTROL' AND 'ENSLAVED' BY THE MACHINES. ALSO IT'S SAD THAT WE HAVE BECOME SO OUT OF TOUCH WITH OUR TECHNOLOGY, SIMPLY BECAUSE IT IS ALL SO WONDERFULLY INGENIOUS. THAT'S WHY THIS SECOND SERIES IS TRYING TO AROUSE CURIOSITY ABOUT AND TO DEMYSTIFY SOME MORE COMMON MACHINES.

THE FIRST MACHINE IN THIS SERIES, THE CAR AND ITS ENGINE, IS SO CENTRAL TO OUR MODERN WAY OF LIFE THAT THERE IS A BIT LESS IGNORANCE ABOUT ITS WORKINGS THAN MOST MACHINES. THE TWO PROGRAMMES CONCENTRATE ON TWO ASPECTS OF THE CAR'S TECHNOLOGY; THE BODYSHELL, WHICH IS RESPONSIBLE FOR ITS SHAPE, STRENGTH, SAFETY AND OBSOLESCENCE; AND THE IDEA OF INTERNAL COMBUSTION, WHICH IS RESPONSIBLE FOR THE ENGINE'S ENORMOUS POWER AND COMPACT SIZE, AND ALSO FOR ITS DISGUSTING EXHAUST.

THE OTHER FOUR MACHINES, THE QUARTZ WATCH, TELEPHONE, RADIO AND VIDEORECORDER ARE HEAVILY DEPENDENT ON ELECTRONICS, THE MOST INSCRUTABLE OF ALL MODERN TECHNOLOGIES. HOWEVER, ALL THE MACHINES HAVE THEIR ORIGINS IN THE LAST CENTURY, LONG BEFORE THE AGE OF ELECTRONICS, AND THE PRINCIPLES BEHIND THEIR WORKINGS ARE ALL ELEGANTLY SIMPLE. THE VICTORIAN PROTOTYPES AND EXPERIMENTS OFTEN SHOW THE PRINCIPLES OF THEIR MODERN COUNTERPARTS EXTREMELY CLEARLY. EVEN IF MAKING RECORDING TAPE OUT OF RUST AND A RADIO RECEIVER OUT OF A 5p PIECE DOESN'T FULLY EXPLAIN HOW VIDEORECORDERS AND FM. RADIOS WORK, IT DOES HELP TO MAKE THEM LESS INTIMIDATING.

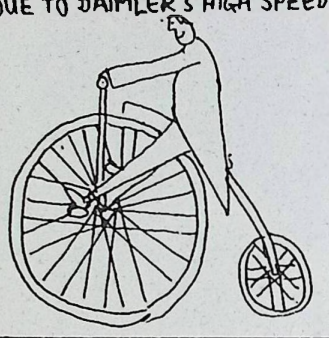
THE BOOKLET ATTEMPTS TO RECAP SOME OF THESE DEMONSTRATIONS BUT THEY ARE DIFFICULT TO EXPLAIN WITH JUST WORDS AND DIAGRAMS SO SOME PARTS ARE A BIT HARD TO UNDERSTAND WITHOUT HAVING SEEN THE RELEVANT PROGRAMME. TO AVOID A COMPLETE BAFFLEMENT, I HAVEN'T ATTEMPTED TO RECAP EVERYTHING AND I'VE ALSO INCLUDED A SELECTION OF ODD FACTS ABOUT THE MACHINES, PARTICULARLY ONES THAT GOT LEFT OUT OF THE FINAL PROGRAMMES.

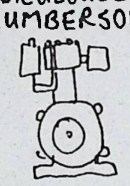
TIM HUNKIN

THE CAR

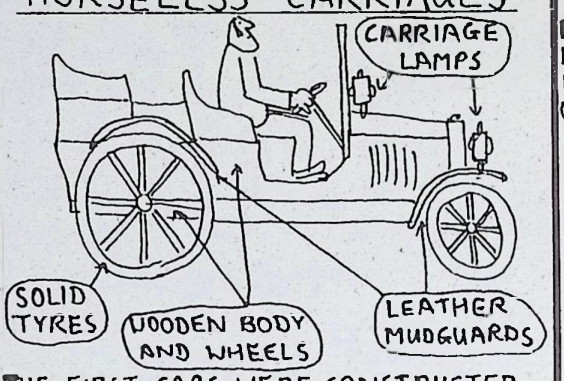
ORIGINS

CARS STARTED TO BECOME POPULAR IN THE 1890s. THEIR SUCCESS WAS PARTLY DUE TO THE BICYCLE, WHICH HAD GIVEN PEOPLE A TASTE FOR A PERSONAL MEANS OF TRANSPORT. IT WAS ALSO DUE TO DAIMLER'S HIGH SPEED ENGINE, THE FIRST INTERNAL COMBUSTION ENGINE TO BE SMALL ENOUGH NOT TO MAKE A VEHICLE RIDICULOUSLY CUMBERSOME.





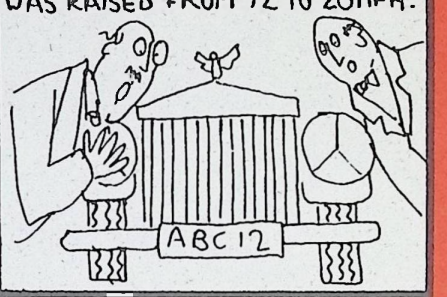
HORSELESS CARRIAGES



THE FIRST CARS WERE CONSTRUCTED JUST LIKE HORSE-DRAWN CARRIAGES.

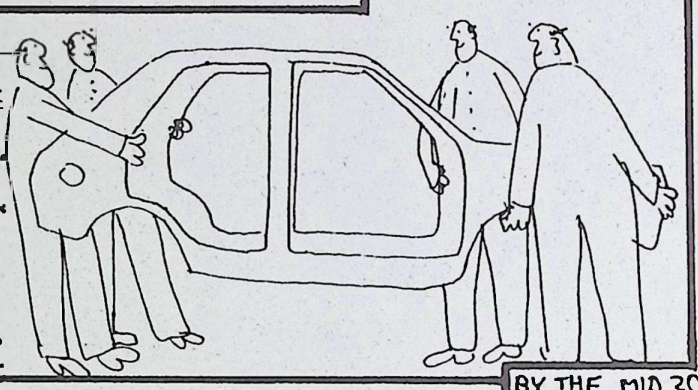
REGISTRATION NUMBERS

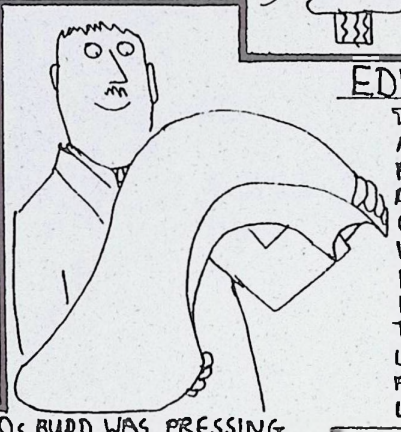
REGISTRATION NUMBERS WERE INTRODUCED IN 1903. THE MOTORING GENTRY GREATLY OBJECTED TO BEING 'NUMBERED LIKE CONVICTS', SO TO SOFTEN THE BLOW, THE SPEED LIMIT WAS RAISED FROM 12 TO 20MPH.



BODYSHELLS

TODAY ALL MASS-PRODUCED CARS ARE BUILT ROUND A STEEL BODYSHELL. THE STEEL IS ONLY ABOUT .7mm THICK & CAN EVEN BE CUT WITH KITCHEN SCISSORS. LIKE AN EGGSHELL, ITS STRENGTH COMES FROM ITS SHAPE.

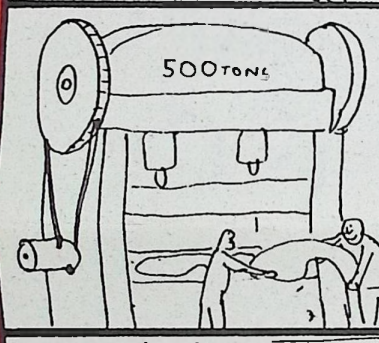




EDWARD BUDD

THE IDEA OF MAKING A CAR FROM THIN STEEL PRESSINGS CAME FROM AN AMERICAN INVENTOR CALLED EDWARD BUDD, WHO PATENTED IT IN 1914. IT WAS A BRAVE IDEA, BECAUSE ONLY TINY PARTS OF DOOR LOCKS & HANDLES HAD PREVIOUSLY BEEN MADE LIKE THIS.

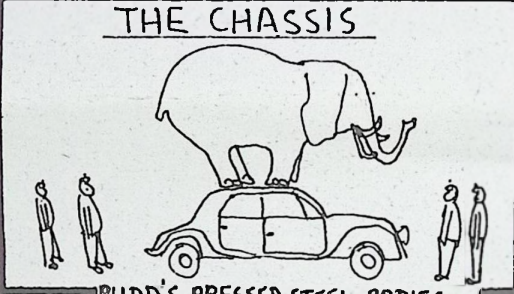
BY THE MID 20s, BUDD WAS PRESSING BODY PANELS FOR ALL THE MAJOR US CAR MAKERS & HAD SET UP A PLANT IN BRITAIN FOR MORRIS (WHICH STILL OPERATES TODAY).



PRESSING & WELDING

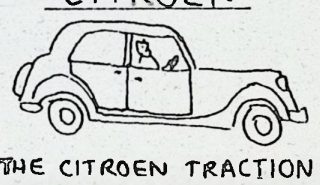
THE STEEL IS PRESSED INTO CURVED, ROUNDED SHAPES BY HUGE 500 TON PRESSES. THE PRESSINGS ARE THEN SPOT WELDED TOGETHER. YOU CAN SEE THE 'SPOTS' ALONG THE SEAMS OF ANY MODERN CAR UNDER THE BONNET.

THE CHASSIS



BUDD'S PRESSED STEEL BODIES WERE MUCH STRONGER THAN THE EARLY WOODEN ONES. HE ROLLED CARS DOWN HILLS & STOOD ELEPHANTS ON THEM TO PROVE IT. HE THEN REALISED HIS BODIES COULD BE MADE SO STRONG THAT THE TRADITIONAL HEAVY STEEL CHASSIS WOULD BE UNNECESSARY. THIS IDEA WAS SLOW TO CATCH ON, BUT TODAY ALL CARS ARE BUILT WITHOUT CHASSIS.

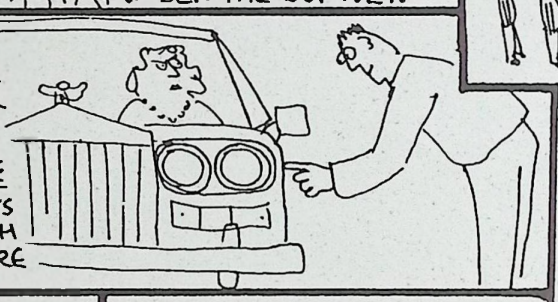
CITROEN



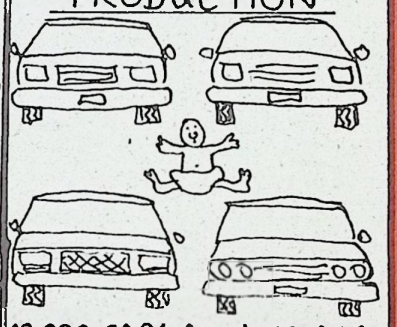
THE CITROEN TRACTION AVANTE OF 1934 WAS THE FIRST CAR TO BE BUILT WITH A STRUCTURAL STEEL BODYSHELL & NO CHASSIS. IT WAS ALSO THE FIRST TO HAVE FRONT WHEEL DRIVE & INDEPENDENT SUSPENSION.

LUXURY

EXPENSIVE CARS ARE MADE OF NO THICKER STEEL THAN CHEAP ONES, ALTHOUGH THE SHELLS TEND TO HAVE MORE STIFFENING BITS WELDED INSIDE, WHICH MAKES THEM FEEL MORE SOLID.



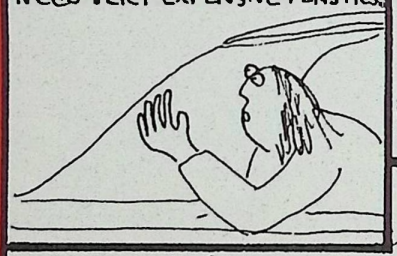
PRODUCTION



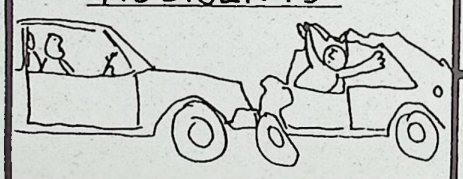
12,000 CARS AN HOUR ARE BEING PRODUCED IN EUROPE, 24 HOURS A DAY. NEARLY FOUR TIMES MORE CARS ARE BEING MADE THAN BABIES ARE BEING BORN.

PLASTICS

SOME EXTERIOR CAR PANELS ARE NOW PLASTIC, BUT THE STRUCTURAL PARTS ARE ALL STILL STEEL, BECAUSE THE ESSENTIAL COMBINATION OF STRENGTH & RIGIDITY WOULD NEED VERY EXPENSIVE PLASTICS.

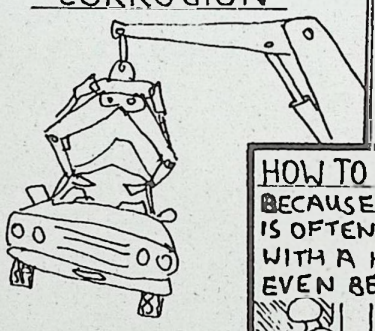


ACCIDENTS



STATISTICS OF INJURIES IN DIFFERENT TYPES OF CAR SHOW THAT THE DETAILED DESIGN IS MUCH LESS IMPORTANT THAN THE OVERALL WEIGHT. THE HEAVIER THE CAR, THE SAFER YOU ARE.

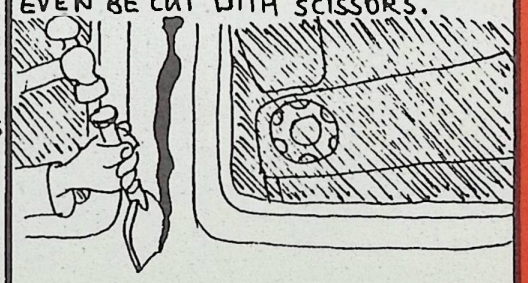
CORROSION



MANUFACTURERS NOW USE GALVANISED STEEL ON SOME OUTER PANELS OF THE BODYSHELL TO REDUCE CORROSION, BUT NONE GALVANISE THE WHOLE SHELL, & 50% OF ALL CARS ARE STILL SCRAPPED BY THE TIME THEY'RE 10 YEARS OLD.

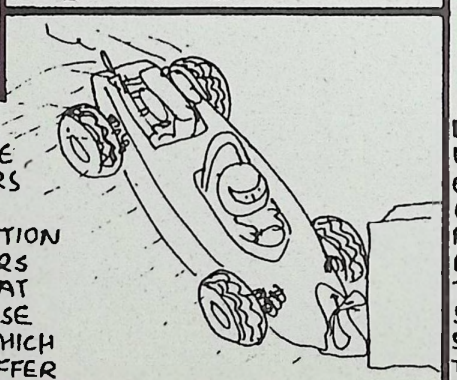
HOW TO CUT A BODYSHELL IN HALF

BECAUSE THE STEEL IS SO THIN, IT IS OFTEN CUT UP BY SPLITTING IT WITH A HAMMER & BOLSTER. IT CAN EVEN BE CUT WITH SCISSORS.



DAMAGE

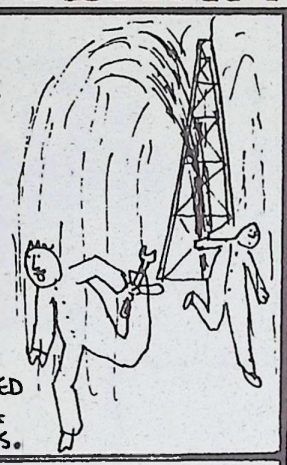
MODERN BODYSHELLS CRUMPLE VERY EASILY. MANUFACTURERS ARGUE THAT THIS ABSORBS ENERGY & REDUCES DECELERATION IN ANY CRASH, MAKING CARS SAFER. CRITICS ARGUE THAT THIS IS AN EXCUSE, BECAUSE DRIVERS OF RACING CARS, WHICH HAVE RIGID STEEL FRAMES, SUFFER HIGH DECELERATION WITHOUT INJURY.



THE INTERNAL COMBUSTION ENGINE

UNWANTED OIL

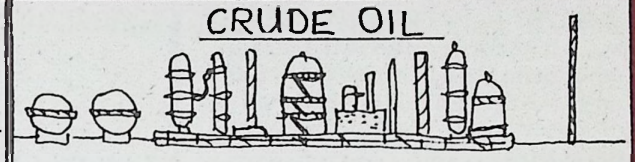
CRUDE OIL NATURALLY SEEPS OUT OF THE GROUND IN PLACES & HAD BEEN USED MEDICINALLY SINCE ANCIENT TIMES. IT WAS FIRST ENCOUNTERED UNDERGROUND IN THE 1840s IN AMERICA DURING ATTEMPTS TO FIND SALT DEPOSITS. AT FIRST NO ATTEMPT WAS MADE TO COLLECT THE OIL, WHICH WAS REGARDED AS A MENACE, SOAKING THE MEN & THEIR TOOLS.



UNWANTED PETROL

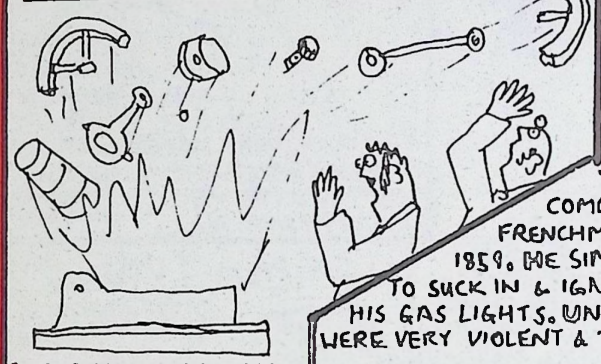
AMERICANS STARTED TO USE CRUDE OIL IN THE 1860s WHEN THEY FOUND IT WAS AN IDEAL FUEL FOR OIL LAMPS, WITH A BIT OF DISTILLATION. A BY-PRODUCT OF THIS DISTILLATION WAS A VOLATILE GAS OIL, OR PETROL. IT WAS REGARDED AS DANGEROUS & USELESS UNTIL THE FIRST CARS APPEARED 30 YEARS LATER.

CRUDE OIL



TODAY, ALMOST EVERYTHING A REFINERY CREATES FROM CRUDE OIL CAN BE USED BY CARS. BESIDES PETROL, IT PROVIDES LUBRICATING OILS, THE CHEMICALS THAT ARE THE BASIS OF PLASTICS, PAINTS & SYNTHETIC RUBBERS, & EVEN THE BITUMEN THE ROADS ARE MADE OF.

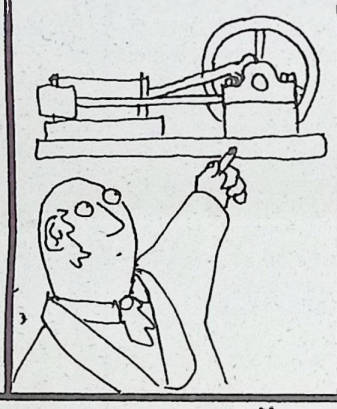
INTERNAL COMBUSTION



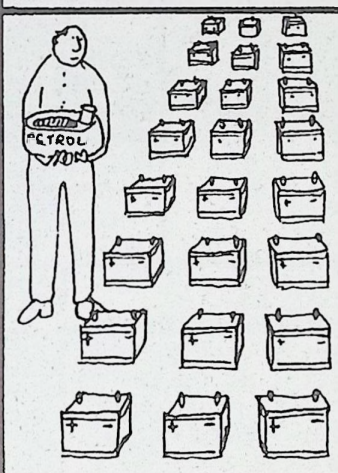
INTERNAL COMBUSTION ENGINES BASICALLY WORK BY HARNESSING THE VIOLENT ENERGY OF EXPLOSIONS. COPING WITH THE MECHANICAL STRESSES, HEAT AND RESIDUES LEFT BY THE COMBUSTION IS NOT EASY, WHICH IS WHY THIS SORT OF ENGINE ONLY BECAME PRACTICAL JUST OVER 100 YEARS AGO, LONG AFTER THE STEAM ENGINE.

LENOIR

THE FIRST WORKING INTERNAL COMBUSTION ENGINE WAS MADE BY A FRENCHMAN CALLED ETIENNE LENOIR IN 1859. HE SIMPLY MODIFIED A STEAM ENGINE TO SUCK IN & IGNITE THE INFLAMMABLE GAS FROM HIS GAS LIGHTS. UNFORTUNATELY THE EXPLOSIONS WERE VERY VIOLENT & THE ENGINE WAS VERY INEFFICIENT.



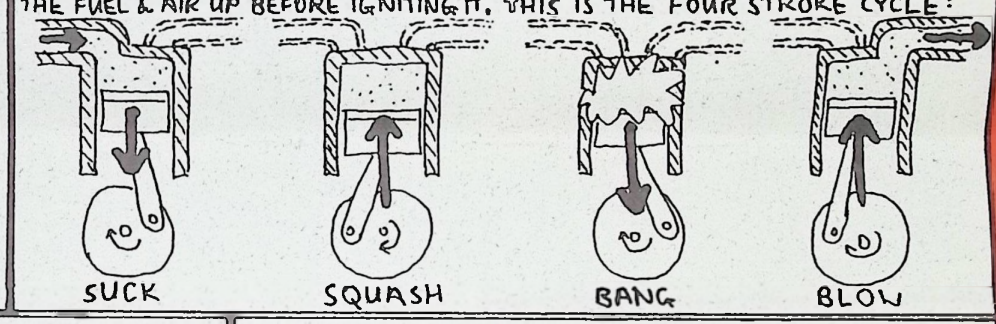
PETROL V ELECTRIC



THE GREAT ATTRACTION OF OIL AS A FUEL IS THAT IT'S SO COMPACT. COMPARED TO THE BATTERIES IN AN ELECTRIC CAR, PETROL PROVIDES OVER TEN TIMES MORE ENERGY FOR THE SAME WEIGHT. ALSO, FILLING UP A TANK OF PETROL TAKES SECONDS, COMPARED TO THE HOURS NEEDED TO CHARGE BATTERIES.

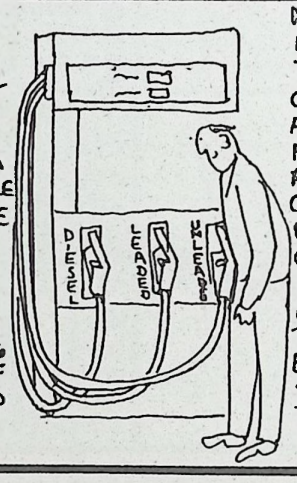
OTTO

THE FIRST SUCCESSFUL ENGINE WAS MADE BY A GERMAN GROCERY SALESMAN CALLED NICOLAS OTTO. HIS BIG IMPROVEMENT WAS TO SQUASH THE FUEL & AIR UP BEFORE IGNITING IT. THIS IS THE FOUR STROKE CYCLE:



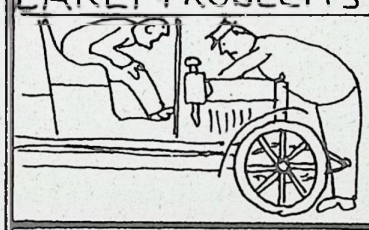
KNOCK

ALTHOUGH THE IGNITION IN A PETROL ENGINE SHOULD BE STARTED BY THE SPARK, PETROL IS A COMPLICATED MIXTURE OF CHEMICALS, SOME OF WHICH ARE QUITE UNSTABLE. THESE CAN IGNITE SPONTANEOUSLY UNDER PRESSURE, CAUSING A SORT OF EXPLOSION CALLED DETONATION OR KNOCK.



KNOCK CAN BE STOPPED EITHER BY 'DAMPING' THE UNSTABLE COMPOUNDS WITH LEAD ADDITIVES, OR, IN LEAD FREE PETROL, BY REFINING THE UNSTABLE COMPOUNDS OUT. THE OTHER OPTION USED ON DIESEL ENGINES, IS TO COMPRESS A LESS REFINED FUEL SO MUCH THAT IT ALWAYS DOES EXPLODE WITHOUT A SPARK, AND MAKE THE ENGINE STRONG ENOUGH TO COPE.

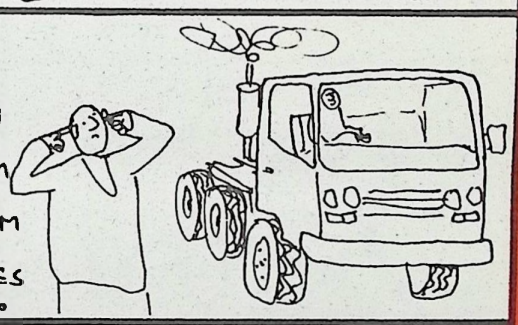
EARLY PROBLEMS

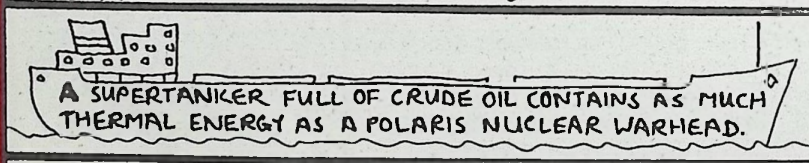


THE FIRST CAR ENGINES HAD CONSIDERABLE DISADVANTAGES. THEY WERE DIFFICULT TO START, USED LOTS OF FUEL, STALLED EASILY, CONTINUALLY LEAKED OIL & HAD TO BE TAKEN TO BITS & CLEANED OUT (DECOKED) EVERY FEW THOUSAND MILES.

DIESEL

DIESEL ENGINES COMPRESS THEIR FUEL MORE THAN PETROL ENGINES. THIS MAKES THEM NOISIER, BUT IT ALSO MAKES THEM MORE EFFICIENT, DOING MORE MILES TO THE GALLON.

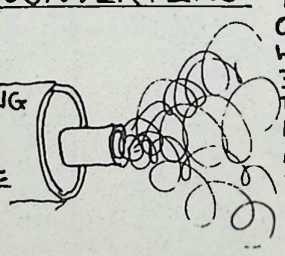




A SUPERTANKER FULL OF CRUDE OIL CONTAINS AS MUCH THERMAL ENERGY AS A POLARIS NUCLEAR WARHEAD.

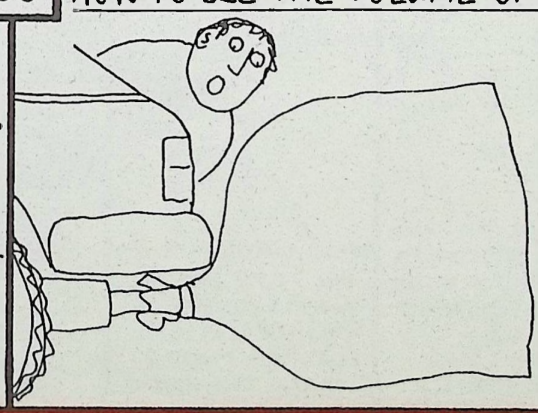
CATALYTIC CONVERTERS

THE PLATINUM CATALYST ENCOURAGES ANY PARTLY BURNT GASES TO COMPLETE THEIR COMBUSTION. THIS HAS THE EFFECT OF CONVERTING THE POISONOUS NITROGEN OXIDES & CARBON MONOXIDE TO NITROGEN AND CARBON DIOXIDE - THE GREENHOUSE GAS.



A RECENT SURVEY IN AMERICA FOUND THAT, IN PRACTICE, CATALYTIC CONVERTERS WERE ONLY ABOUT 30% EFFICIENT AS THE AIR TO FUEL RATIO HAS TO BE EXACTLY RIGHT FOR THEM TO WORK, & THE CATALYST ITSELF CAN EASILY GET POISONED & STOP WORKING.

HOW TO SEE THE VOLUME OF YOUR EXHAUST

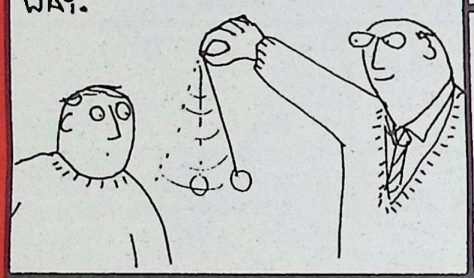


WITH THE ENGINE SWITCHED OFF AND COLD, FIX A DUSTBIN BAG OVER THE EXHAUST PIPE WITH SELLOTAPE. NOW SWITCH ON ENGINE & SEE HOW FAST BAG FILLS. AN AVERAGE CAR RELEASES FOUR TIMES ITS WEIGHT IN EXHAUST GASES DURING ITS LIFE.

THE QUARTZ WATCH

COUNTING CLOCKS

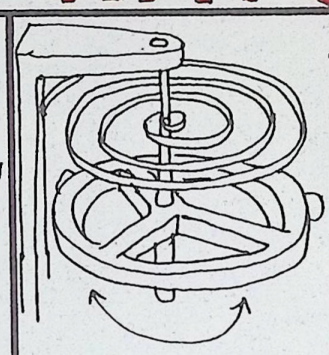
ALL CLOCKS & WATCHES WORK BY 'COUNTING' SOME EVENT WHICH TAKES A FIXED PERIOD OF TIME, LIKE THE SWINGS OF A PENDULUM. THE HIGHER IT GOES THE STRONGER THE PULL OF GRAVITY & THE FASTER IT COMES BACK - SO THE SWINGS ALWAYS TAKE A FIXED TIME. THE QUARTZ CRYSTAL IN A WATCH VIBRATES AT A FIXED SPEED IN A SIMILAR WAY.



NUREMBERG EGGS

THE EARLIEST PORTABLE CLOCKS (c1550) ARE KNOWN AS NUREMBERG EGGS. THEY WERE DESIGNED TO BE HUNG FROM THE NECK LIKE THE SCENT BOTTLES OF THE PERIOD.

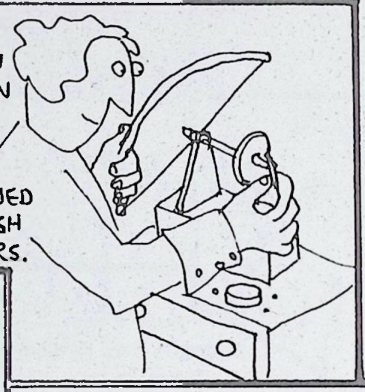
HAIRSPRINGS

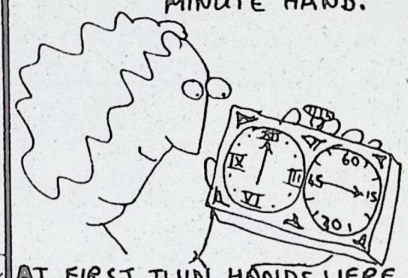


THE HAIRSPRING OF A WATCH HAS THE SAME FUNCTION AS GRAVITY ON A PENDULUM,. PULLING THE BALANCE WHEEL BACK TO THE MIDDLE. INTRODUCED BY THE DUTCH SCIENTIST HUYGENS IN 1675, IT MADE WATCHES ACCURATE ENOUGH TO HAVE A MINUTE HAND.

JEWELS

JEWELS WERE FIRST USED IN 1671 TO REDUCE FRICTION IN BEARINGS. THE METHOD OF DRILLING HOLES THROUGH THE JEWELS (DRILL BITS COATED IN DIAMOND) REMAINED THE SECRET OF A FEW ENGLISH WATCHMAKERS FOR 100 YEARS.

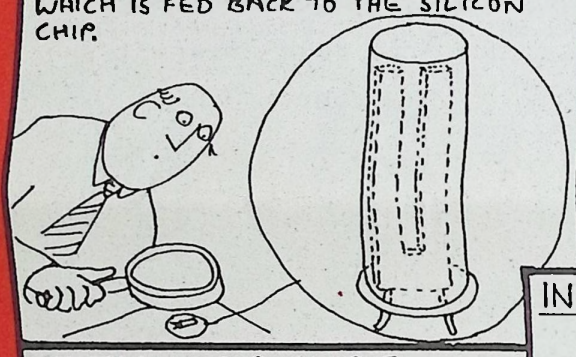




AT FIRST TWIN HANDS WERE FOUND VERY CONFUSING SO THE MINUTES WERE PUT ON A SEPARATE DIAL.

VIBRATING QUARTZ

ELECTRICITY CAN DISTORT VARIOUS CRYSTALS, INCLUDING QUARTZ. THIS IS CALLED THE PIEZO ELECTRIC EFFECT & IN THE WATCH IT'S USED TO VIBRATE A TINY BIT OF QUARTZ LIKE A TUNING FORK. THE PIEZOELECTRIC EFFECT WORKS IN REVERSE SO THE VIBRATION OF THE CRYSTAL ACTUALLY PRODUCES A TINY ELECTRICAL SIGNAL WHICH IS FED BACK TO THE SILICON CHIP.



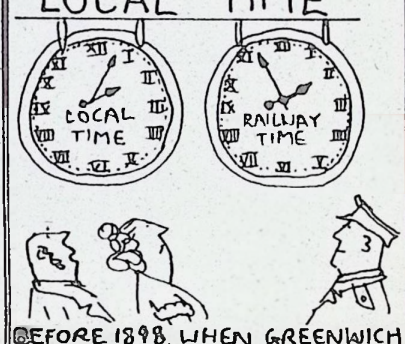
GAS LIGHTERS

GAS LIGHTERS ALSO WORK BY PIEZO-ELECTRICITY. THE MECHANISM DISTORTS A CRYSTAL BY SQUASHING IT & THIS CREATES ENOUGH ELECTRICITY TO MAKE A SPARK.

OIL

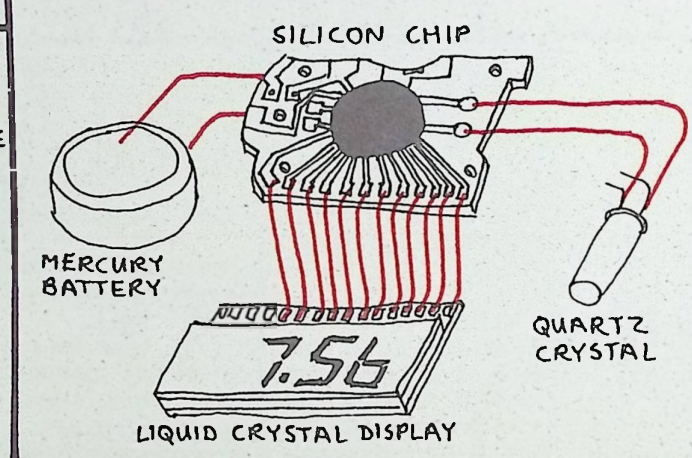
OIL IS THE BANE OF ALL MECHANICAL WATCHES. AFTER A TIME IT FORMS A HARD COATING LIKE VARNISH OR A GRINDING PASTE WITH THE DUST FROM THE AIR. PLASTIC GEARS NEED NO LUBRICATION & ARE NOW BECOMING VERY COMMON.

LOCAL TIME



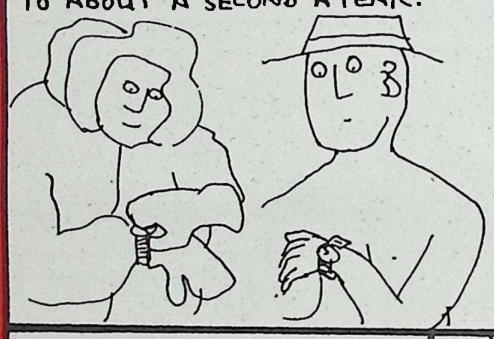
BEFORE 1898, WHEN GREENWICH MEAN TIME WAS INTRODUCED ACROSS THE COUNTRY, EACH TOWN SET ITS CLOCKS FROM SUNDIALS & KEPT SLIGHTLY DIFFERENT TIME (PLYMOUTH WAS ABOUT 15 MINUTES BEHIND LONDON). STATIONS OFTEN HAD TWO CLOCKS ONE FOR LOCAL TIME & ONE FOR RAILWAY TIME.

INSIDE A DIGITAL QUARTZ WATCH

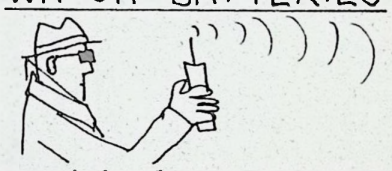


TEMPERATURE

ALTHOUGH QUARTZ VIBRATES AT A VERY ACCURATE FIXED SPEED, IT IS SLIGHTLY AFFECTED BY TEMPERATURE CHANGES. PRECISION QUARTZ CLOCKS HAVE THEIR CRYSTALS ENCLOSED IN A CONSTANT TEMPERATURE OVEN WHICH INCREASES THEIR ACCURACY TO ABOUT A SECOND A YEAR.

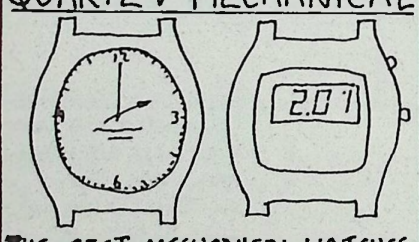


WATCH BATTERIES



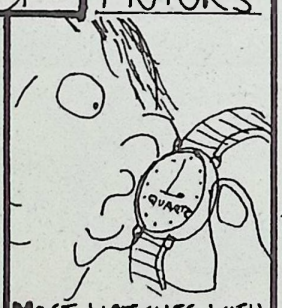
WATCH BATTERIES WERE FIRST DEVELOPED DURING THE SECOND WORLD WAR FOR LIGHTWEIGHT RADIOS & PERFECTED IN THE FIFTIES FOR SPIES' RADIOS.

QUARTZ V MECHANICAL



THE BEST MECHANICAL WATCHES COSTING THOUSANDS OF POUNDS, ARE ACCURATE TO ABOUT A SECOND A DAY. THE CHEAPEST QUARTZ WATCHES ARE JUST AS ACCURATE, & GOOD ONES ARE TEN TIMES MORE ACCURATE.

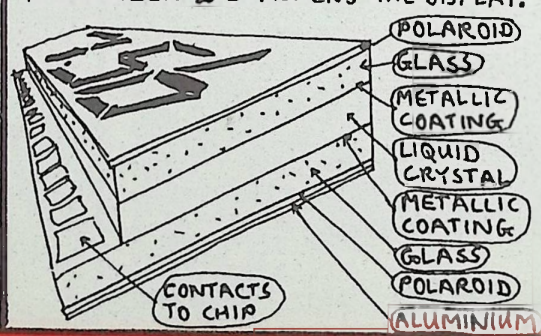
QUARTZ AND MOTORS



MOST WATCHES WITH DIALS ARE NOW QUARTZ CONTROLLED. THEY HAVE A TINY ELECTRIC MOTOR DRIVING THE HANDS.

LIQUID CRYSTAL DISPLAYS

LIQUID CRYSTAL DISPLAYS WORK BY BLOCKING LIGHT BY POLARISATION, THE SAME EFFECT AS ROTATING ONE LENS OF A PAIR OF POLAROID SUNGLASSES IN FRONT OF THE OTHER. A SMALL ELECTRIC CHARGE ACROSS THE TWO BITS OF GLASS CHANGES THE POLARISATION OF THE LIQUID CRYSTAL IN BETWEEN & BLACKENS THE DISPLAY.



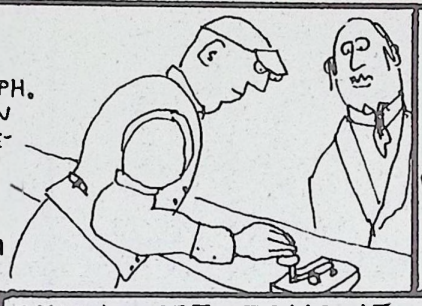
HOW TO MAKE A SECRET WATCH

CAREFULLY TAKE A CHEAP DIGITAL WATCH TO BITS. PRIZE POLAROID PLASTIC OFF TOP OF LIQUID CRYSTAL DISPLAY & REASSEMBLE WATCH. THE DISPLAY WILL NOW BE INVISIBLE UNTIL LOOKED AT THROUGH POLAROID SUNGLASSES.

THE TELEPHONE

THE TELEGRAPH

THE FORERUNNER OF THE TELEPHONE WAS THE TELEGRAPH. BY 1870 ALL MAJOR TOWNS IN EUROPE & AMERICA HAD TELEGRAPHS, SENDING MESSAGES IN ON & OFF PULSES (ES MORSE CODE). IT WAS WHILE TRYING TO IMPROVE THE TELEGRAPH THAT BELL DISCOVERED THE TELEPHONE.

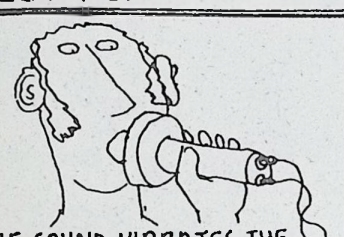


ALEXANDER GRAHAM BELL

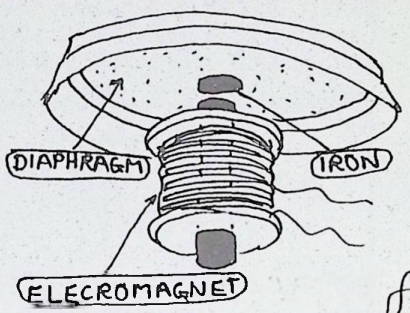
BELL'S FATHER WAS AN EBULLIENT TEACHER OF SPEECH & ELOCUTION WHO LIVED IN EDINBURGH. HE MOVED TO AMERICA AFTER ALEXANDER'S TWO BROTHERS DIED OF TUBERCULOSIS. ALEXANDER ADDED THE GRAHAM TO HIS NAME HIMSELF, AGED ELEVEN.

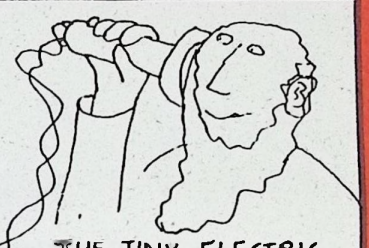
BELL'S TELEPHONE

BELL'S TELEPHONE WAS ELEGANTLY SIMPLE. HE FITTED A DIAPHRAGM OVER AN ELECTROMAGNET & MADE IT WORK BOTH AS A MICROPHONE & EARPIECE. IT WASN'T REALLY LOUD ENOUGH TO BE PRACTICAL AT THE TIME, BUT WITH MODERN TRANSISTOR AMPLIFIERS, IT IS NOW WIDELY USED (SEE BELOW: HOW TO MAKE A MINIATURE INTERCOM).

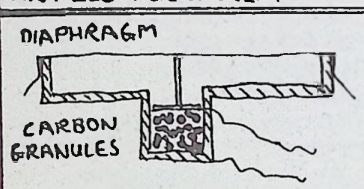


THE SOUND VIBRATES THE DIAPHRAGM, MOVING THE IRON & CHANGING THE MAGNETIC FIELD ROUND THE ELECTROMAGNET. THIS CREATES TINY ELECTRIC CURRENTS IN THE WIRE.



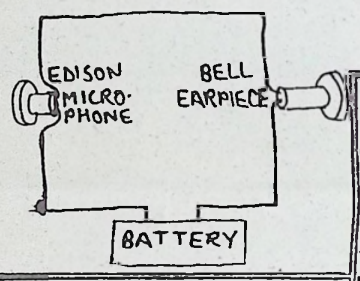


THE TINY ELECTRIC CURRENTS FROM THE MICROPHONE ENERGISE THE ELECTROMAGNET, ATTRACT THE IRON & VIBRATE THE DIAPHRAGM, RECREATING THE SOUND.



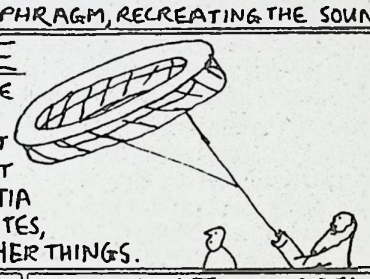
THE PRACTICAL TELEPHONE

THE VOLUME OF THE TELEPHONE WAS INCREASED BY A DIFFERENT SORT OF MICROPHONE. INVENTED BY THOMAS EDISON & A REVEREND HUNNINGS. THIS WAS SIMPLY A DIAPHRAGM & A PILE OF CARBON GRANULES. SPEECH VARIED THE PRESSURE ON THE CARBON GRANULES & ALTERED THEIR ELECTRICAL RESISTANCE.



BELL'S FORTUNE

BELL MADE HIS FORTUNE FROM HIS TELEPHONE PATENT BUT THEN LOST INTEREST IN IT. HE BUILT A MANSION IN NOVIA SCOTIA & EXPERIMENTED WITH KITES, HYDROFOILS, & MANY OTHER THINGS.



CRACKLING

THE DISADVANTAGE OF CARBON MICROPHONES IS THAT THE GRANULES TEND TO CRACKLE WHEN MOVED. THE EARLY TELEPHONE MICROPHONES WERE FIRMLY FIXED TO THE WALL TO PREVENT THIS. MODIFIED DESIGNS CARRIED ON BEING MADE UNTIL THE 1970s & MANY ARE STILL IN USE, CRACKLING AWAY.

THE FIRST EXCHANGE

THE FIRST TELEPHONE EXCHANGE WAS OPENED BY THE HOLMES BURGLAR ALARM COMPANY, BOSTON US. THEY ALREADY HAD LINES TO THEIR CLIENTS CONNECTING THE ALARMS, SO THEY SIMPLY USED THE LINES FOR TELEPHONES DURING THE DAY, WITH AN OPERATOR TO PUT PEOPLE THROUGH.

THE AUTOMATIC EXCHANGE

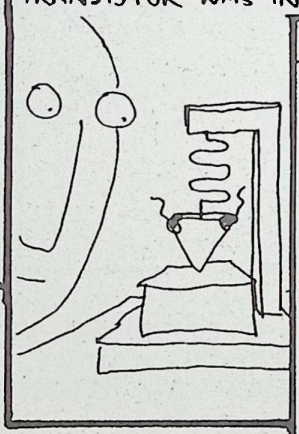
THE FIRST AUTOMATIC EXCHANGE WAS INVENTED BY AN EXASPERATED KANSAS CITY UNDERTAKER, ALMON. B. STROWGER, IN 1889. THE RIVAL UNDERTAKER'S WIFE WAS A TELEPHONE OPERATOR & USED TO PUT PEOPLE THROUGH TO HER HUSBAND INSTEAD OF STROWGER.

THE FIRST PHONES

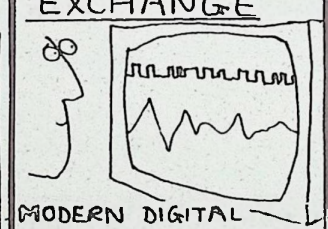
WHEN THE TELEPHONE FIRST APPEARED IN ENGLAND SOME PEOPLE REFUSED TO SPEAK TO ANYBODY THEY DID NOT KNOW, INSISTING THAT THEY FIRST CALLED & LEFT THEIR VISITING CARD 'IN A PROPER MANNER'.

THE BELL LABORATORY

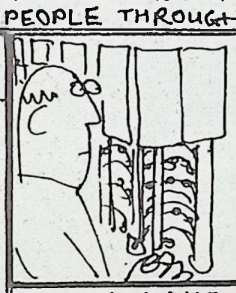
AS THE TELEPHONE SYSTEM GREW, THE BELL COMPANY ESTABLISHED A LABORATORY IN 1912. IT WAS WHILE SEARCHING FOR A SOLID STATE SWITCH TO REPLACE THE STROWGER EXCHANGES THAT THE TRANSISTOR WAS INVENTED IN 1947.



THE DIGITAL EXCHANGE

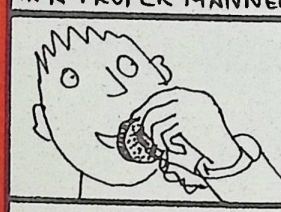


MODERN DIGITAL EXCHANGES CONVERT TELEPHONE CONVERSATIONS TO A DIGITAL CODE. LIKE THE DIGITAL SOUND ON COMPACT DISKS, THIS GIVES A BETTER QUALITY & ENABLES IT TO BE SWITCHED BY DIGITAL COMPUTERS.

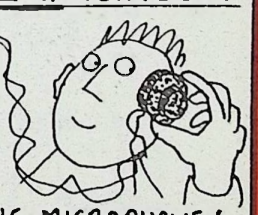


STROWGER'S LONGEVITY

STROWGER EXCHANGES WERE BUILT UP UNTIL THE 1970s & MANY ARE STILL IN USE. THEY ARE RESPONSIBLE FOR MOST 'CROSSED LINES', THEY NEED FREQUENT ADJUSTMENT, & THEY GRADUALLY WEAR DOWN DROPPING SMALL PILES OF METAL FILINGS.



HOW TO MAKE A MINIATURE INTERCOM

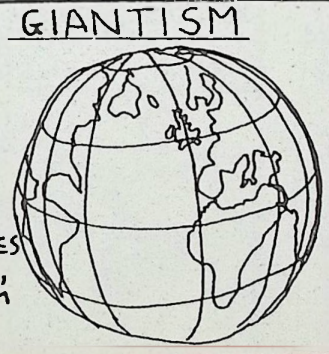


THE MICROPHONE & EARPIECE OF MOST MODERN PHONES ARE IDENTICAL, JUST LIKE BELL'S. YOU CAN CONNECT THEM DIRECTLY TOGETHER, WITHOUT ANY BATTERY.

SHAPES

WITH ELECTRONICS, THERE IS NO NEED FOR THE BULKY DIAL & BELL MECHANISM, & TELEPHONES HAVE LOST THEIR DISTINCTIVE, ROBUST APPEARANCE. TODAY THEY CAN BE ALMOST ANY SIZE OR SHAPE.

GIANTISM

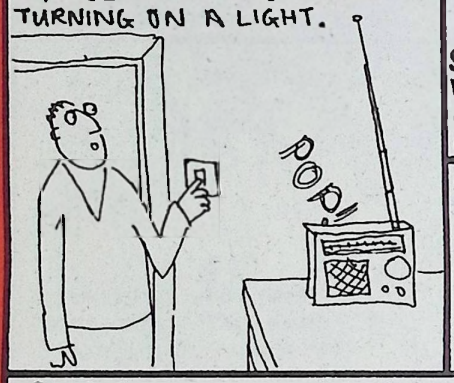


BECAUSE THE TELEPHONE SYSTEMS IN DIFFERENT COUNTRIES ARE NOW ALL INTERCONNECTED, THE GLOBAL TELEPHONE SYSTEM IS TODAY THE BIGGEST MACHINE OF ANY SORT IN THE WORLD.

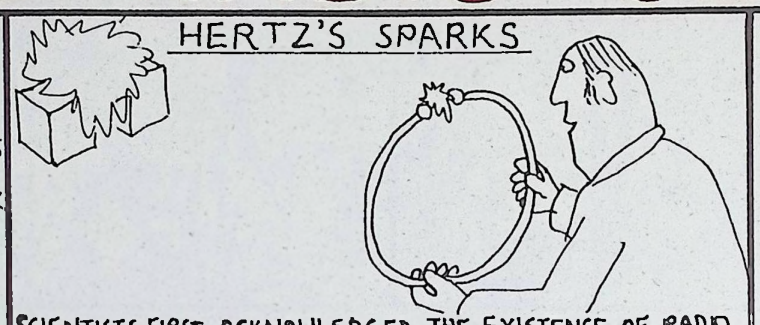
THE RADIO SET

SPARKS

ANY ELECTRICAL SPARK CREATES RADIO WAVES & ACTS AS A TRANSMITTER. YOU HEAR SPARKS ON A RADIO AS INTERFERENCE. THAT'S WHY LIGHTNING MAKES RADIOS CRACKLE, & EVEN THE TINY SPARK IN A SWITCH IS ENOUGH TO MAKE A NOISE ON THE RADIO WHEN TURNING ON A LIGHT.



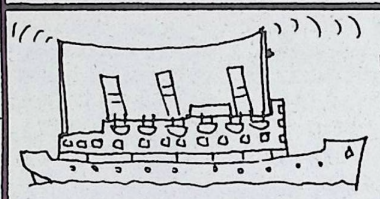
HERTZ'S SPARKS



SCIENTISTS FIRST ACKNOWLEDGED THE EXISTENCE OF RADIO WAVES IN 1887 WHEN HEINRICH HERTZ FOUND THAT A BIG SPARK COULD MAKE A TINY SPARK JUMP ACROSS THE GAP OF A COPPER RING SEVERAL METRES AWAY.

MARCONI

GUGLIELMO MARCONI, STILL IN HIS EARLY 20s, WAS THE FIRST PERSON TO USE RADIO WAVES FOR SIGNALLING. HE INCREASED THE RANGE OF HERTZ'S APPARATUS BY ADDING LONG AERIALS (WIRES HELD UP BY KITES) & MORE SENSITIVE RECEIVERS CALLED COHERERS.

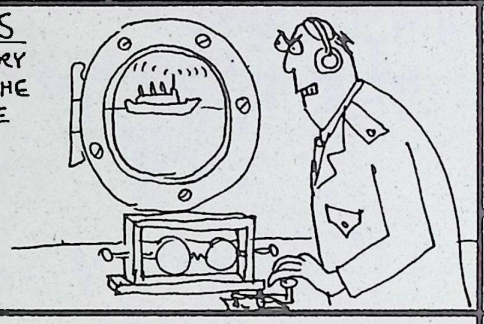


SPARKS AT SEA

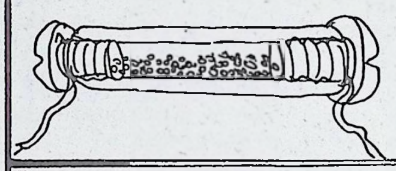
MARCONI'S RADIO WAS FIRST USED FOR COMMUNICATION AT SEA. SHIP'S RADIO OPERATORS ARE STILL CALLED SPARKS AFTER THE EARLY TRANSMITTERS.

CHAOTIC SPARKS

ALTHOUGH SPARKS MAKE VERY EFFECTIVE TRANSMITTERS, THE RADIO WAVES THEY CREATE ARE VERY CHAOTIC AND TRANSMIT OVER THE ENTIRE LONG & MEDIUM WAVEBAND. THIS MEANT THAT ONLY ONE SPARK TRANSMITTER COULD BE USED IN ANY AREA.



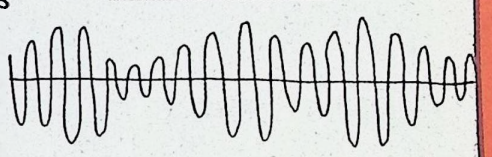
THE COHERER



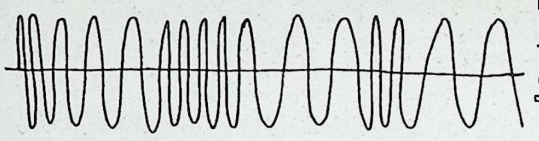
THE COHERER IS SIMPLY A TUBE OF SILVER OR NICKEL FILINGS, WHICH DETECT RADIO WAVES BY 'COHERING', DROPPING THEIR ELECTRICAL RESISTANCE & SWITCHING ON A CIRCUIT.

A.M. RADIO

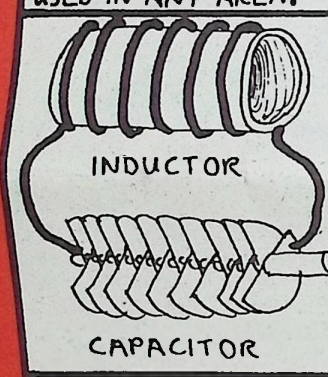
RADIO WAVES CAN TRANSMIT SOUND WAVES BY COMBINING THEM IN A PROCESS CALLED MODULATION. IN AMPLITUDE MODULATION THE SOUND VARIES THE STRENGTH OF THE RADIO WAVES.



F.M. RADIO



IN FREQUENCY MODULATION, THE SOUND VARIES THE WAVELENGTH OF THE RADIO WAVES. THIS MAKES IT LESS SUSCEPTIBLE TO INTERFERENCE.



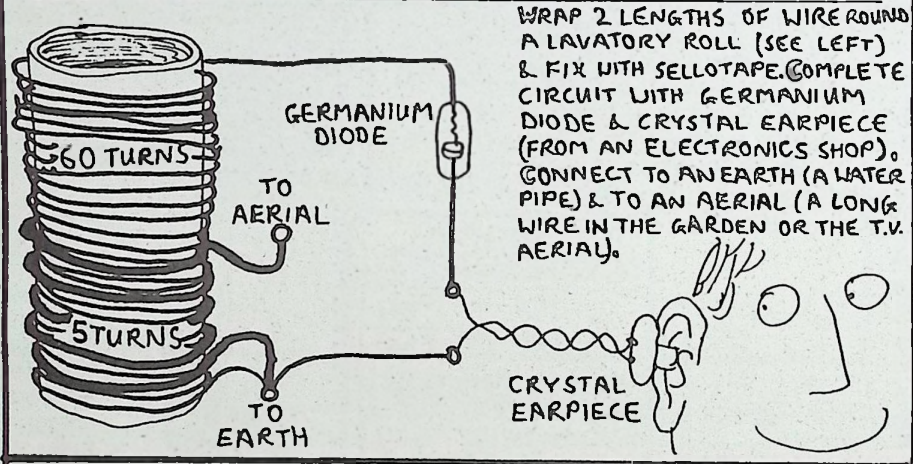
TUNED CIRCUITS

SPARK TRANSMITTERS WERE REPLACED WITH TUNED CIRCUITS THAT TRANSMIT AT ONE WAVELENGTH ONLY. TUNED CIRCUITS HAVE AN INDUCTOR (A COIL OF WIRE) AND A CAPACITOR (OVERLAPPING METAL PLATES). THE ELECTRICITY WHIZZES BACK & FORTH BETWEEN THE TWO, OSCILLATING THOUSANDS OF TIMES A SECOND. THEY ARE USED WITH TRANSISTORS OR VALVES, WHICH ACT LIKE PUMPS, KEEPING THE OSCILLATION GOING.

BROADCAST RADIO

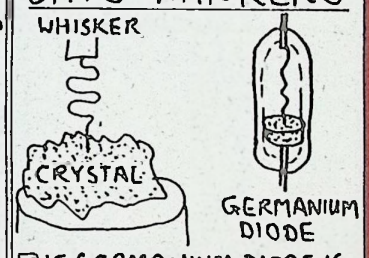
THE FIRST ENTERTAINMENT BROADCAST WAS A RECITAL BY DAME NELLIE MELBA IN 1920, TRANSMITTED BY THE MARCONI COMPANY. THE POST OFFICE THEN BANNED FURTHER ENTERTAINMENT, SAYING IT WAS TRIVIAL & INTERFERED WITH LEGITIMATE TRANSMISSIONS. THEY EASED THE BAN A YEAR LATER, ALLOTTING 15 MINUTES ENTERTAINMENT PER WEEK.

HOW TO MAKE A RADIO WITHOUT BATTERIES



WRAP 2 LENGTHS OF WIRE ROUND A LAVATORY ROLL (SEE LEFT) & FIX WITH SELLOTAPE. COMPLETE CIRCUIT WITH GERMANIUM DIODE & CRYSTAL EARPIECE (FROM AN ELECTRONICS SHOP). CONNECT TO AN EARTH (A WATER PIPE) & TO AN AERIAL (A LONG WIRE IN THE GARDEN OR THE T.V. AERIAL).

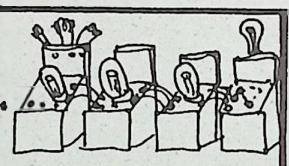
CATS' WHISKERS



THE GERMANIUM DIODE IS AN ENCLOSED VERSION OF THE OLD CRYSTAL & CAT'S WHISKER. WHEN A WIRE TOUCHES CERTAIN CRYSTALS (SEMICONDUCTORS), ELECTRICITY WILL FLOW IN ONLY ONE DIRECTION. THIS CUTS OUT HALF OF ANY RADIO WAVE, LEAVING IT IN A FORM THAT CAN BE PICKED UP BY A SENSITIVE EARPIECE.

RADIO SETS

THE EARLY RADIOS WERE SOLD IN SEPARATE PARTS. YOU JOINED THEM TO FORM A 'SET' LIKE A MODERN HI-FI STACK.



TRANSISTORS

RADIOS WERE BULKY OBJECTS CONSUMING LOTS OF POWER HEATING THE VALVES, UNTIL THE INTRODUCTION OF THE FIRST TRANSISTOR RADIOS IN 1955.

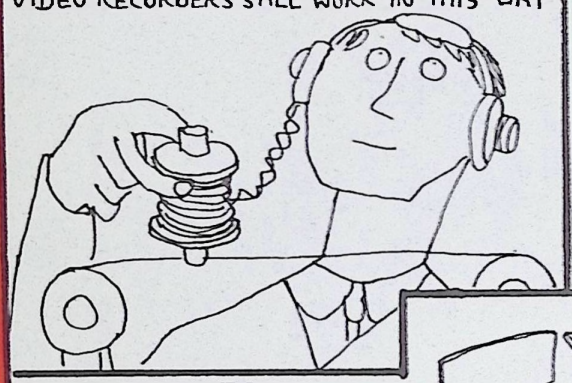
TOOTH RADIO

PEOPLE OCCASIONALLY HEAR THE RADIO INSIDE THEIR HEADS. CARBORUNDUM FROM DENTISTS' DRILLS CAN ACT AS A CAT'S WHISKER & PICK UP POWERFUL RADIO SIGNALS.

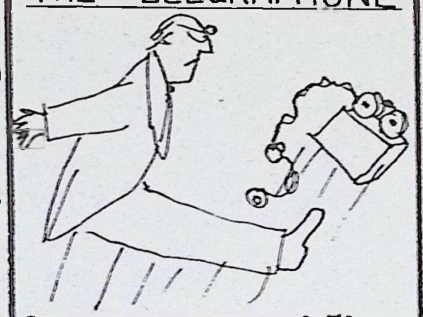
★ THE VIDEORECORDER ★

MAGNETIC RECORDING

THE PRINCIPLE OF MAGNETIC RECORDING WAS INVENTED BY A DANISH TELEPHONE ENGINEER CALLED VALDEMAR POULSEN IN 1899. HE USED AN ELECTROMAGNET TO RECORD THE TINY ELECTRIC CURRENTS FROM A TELEPHONE TO MAGNETISE A STEEL WIRE. THIS RECREATED TINY CURRENTS IN THE ELECTROMAGNET WHEN IT WAS REPLAYED. ALL TAPE & VIDEO RECORDERS STILL WORK IN THIS WAY



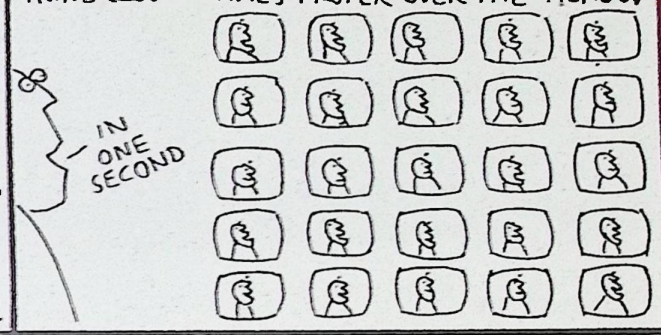
THE TELEGRAPHONE



POULSEN WAS TRYING TO RECORD BUSINESS TRANSACTIONS CONDUCTED BY TELEPHONE TO MAKE THEM LEGALLY BINDING. UNFORTUNATELY, WITHOUT ELECTRONIC AMPLIFICATION, HIS MACHINE, CALLED THE TELEGRAPHONE, NEVER HAD ENOUGH VOLUME TO BE USABLE.

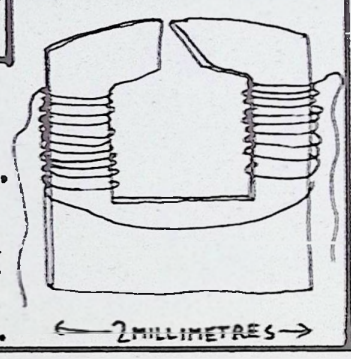
SOUND V PICTURES

THE FIRST PRACTICAL AUDIO TAPE RECORDERS APPEARED IN THE EARLY 30s BUT THE VIDEO-RECORDER DIDN'T APPEAR FOR ANOTHER 25 YEARS. THE PROBLEM IS THAT IN A SECOND AN AUDIO RECORDER ONLY HAS TO RECORD ABOUT 3 WORDS, WHEREAS A VIDEO RECORDER HAS TO RECORD 25 COMPLETE PICTURES, SO THE TAPE HAS TO MOVE HUNDREDS OF TIMES FASTER OVER THE HEADS.

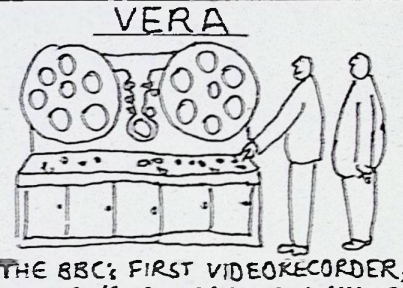


TAPE HEADS

TAPE HEADS ARE ELECTRO-MAGNETS - COILS OF WIRE WRAPPED ROUND TINY RINGS. THE GAP IN EACH HEAD OF A VHS RECORDER IS EXACTLY TWO THOUSANDTH OF A MILLI-METRE. THEY ARE THE MOST ACCURATELY ENGINEERED PART OF ANY DOMESTIC MACHINE.



VERA



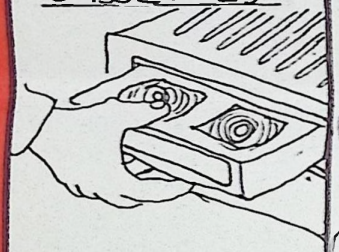
THE BBC's FIRST VIDEORECORDER, CALLED VERA, WAS LIKE A HUGE AUDIO RECORDER, BUT MOVED THE TAPE AT VERY HIGH SPEED (120 MPH)

AMPEX

THE FIRST PRACTICAL VIDEORECORDERS USED A SPINNING TAPE HEAD WHICH RECORDED IN DIAGONAL STRIPES ACROSS THE 50mm WIDE TAPE, WHICH MOVED AT ONLY 2·5 MPH. IT WAS INTRODUCED IN 1956 BY THE US COMPANY AMPEX.

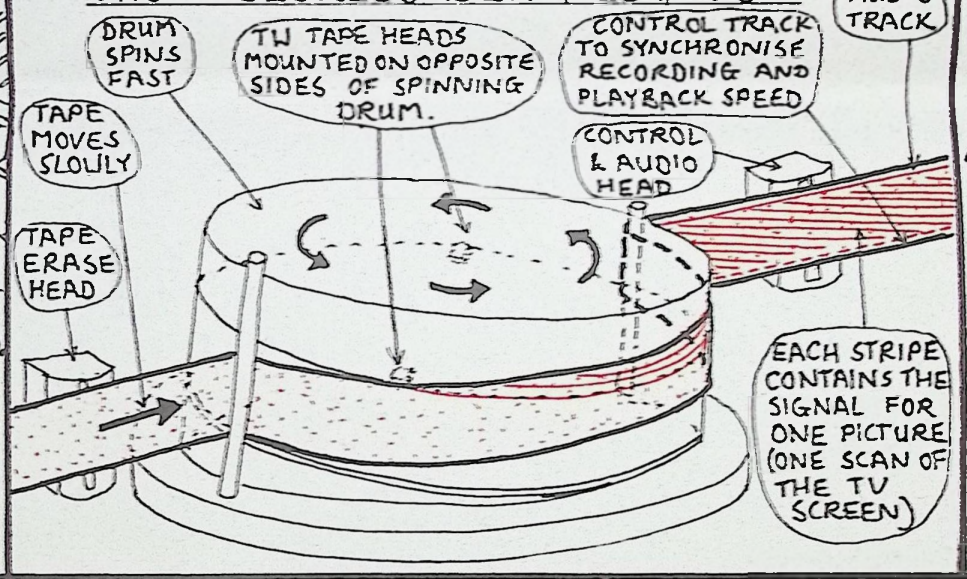
AMPEX WAS FOUNDED BY AM. PONTIATOFF, AND NAMED AFTER HIS INITIALS, PLUS EX FOR EXCELLENCE. HE MADE CURLING TONGS AND OPENED A HAIRDRESSER'S SHOP NEXT TO HIS WORKS FOR TESTING THEM. HE STARTED MAKING AUDIO TAPE RECORDERS AFTER WORLD WAR TWO AFTER ACQUIRING A CAPTURED GERMAN MILITARY RECORDER.

CASSETTES

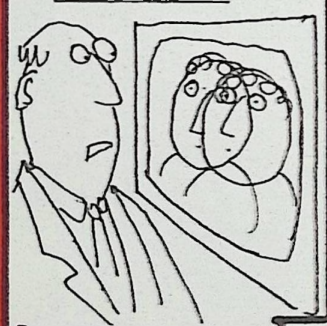


MANY PROFESSIONAL VIDEO-RECORDERS STILL USE REELS OF TAPE THREADED BY HAND. HOWEVER, VIDEO HEADS ARE VERY FRAGILE, & CAN EASILY BE DAMAGED BY CLUMSY THREADING, SO DOMESTIC MACHINES HAVE ALWAYS USED CASSETTES. FIRST TO APPEAR WAS THE PHILLIPS N1500, INTRODUCED IN 1973.

VHS VIDEORECORDER MECHANISM



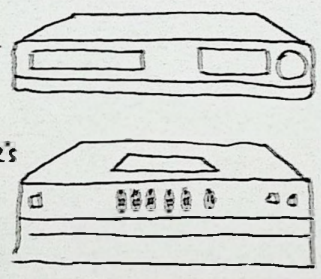
COLOUR



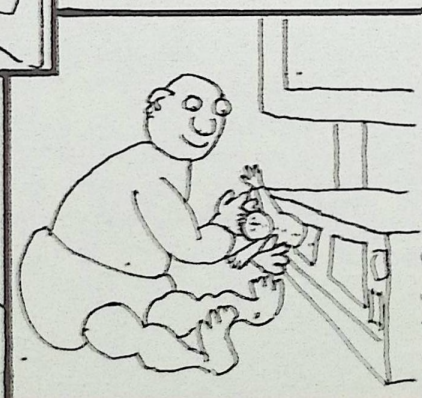
COLOUR IS RECORDED SEPARATELY FROM THE BLACK & WHITE SIGNAL ON ALL DOMESTIC VIDEO-RECORDERS. THIS SHOWS UP WHEN YOU RECORD FROM ONE TAPE TO ANOTHER & THE COLOUR STOPS FITTING THE PICTURE EXACTLY.

CHIPS

LARGE SCALE INTEG-RATED CIRCUITS HAVE, IN THE LAST 10 YEARS, HALVED THE VIDEORECORDER'S WEIGHT, PRICE (ADJUSTED FOR INFLATION) AND NUMBER OF PARTS.



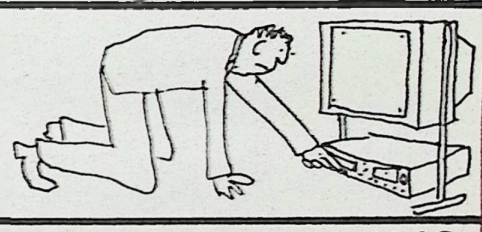
FAULTS



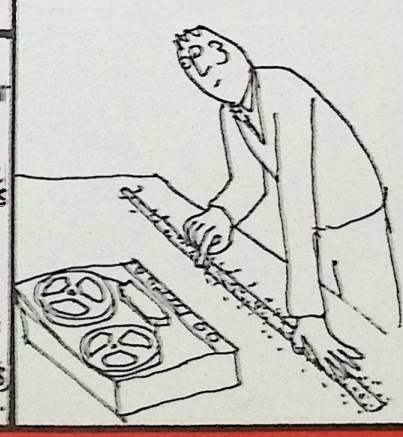
ONE OF THE MOST COMMON CAUSES OF FAULTS IN MODERN DOMESTIC VIDEORECORDERS IS OBJECTS PUSHED INTO THE CASSETTE SLOT BY CHILDREN. THESE INCLUDE TOY CARS, SAUSAGE ROLLS, SANDWICHES & ORANGE JUICE.

TIMERS

A RECENT SURVEY OF VIDEO OWNERS FOUND THAT OVER 70% COULD NOT SET THEIR TIMERS.



HOW TO MAKE MAGNETIC TAPE



MOST RECORDING TAPE IS BASICALLY A CLEAR PLASTIC BACKING WITH A COATING OF A SLIGHTLY MAGNETIC FORM OF RUST (MADE BY HEATING BLACK MAGNETIC OXIDE, Fe_3O_4). A PRIMITIVE TAPE CAN BE MADE BY RUBBING THE RUST POWDER ON TO A LENGTH OF SELLOTAPE & RUNNING IT THROUGH AN OLD AUDIO RECORDER. THE QUALITY IS AMAZINGLY GOOD.

FURTHER READING

- A TECHNICAL HISTORY OF THE MOTOR CAR
  NEWCOMBE & SPURR
  ADAM HILGER, 89
- A HISTORY OF TECHNOLOGY, VOLS 4-6
  SINGER, HOLMYARD, HALL & WILLIAMS
  OXFORD UNIVERSITY PRESS, 78
- IDEAS THAT MOVE AMERICA
  THE BUDD COMPANY
  PHILADELPHIA, USA
- DIESEL, THE MAN & THE ENGINE
  MORTON GROSSER
  DAVID & CHARLES, 80
- NEW INTERNATIONALIST MAGAZINE
  MAY 89
  NEW INTERNATIONALIST
- GUINNESS BOOK OF CAR FACTS & FEATS
  HARDING
  GUINNESS 71
- THE HISTORY OF CLOCKS & WATCHES
  BRUTON
  ORBIS 79
- INTERPRETING INVENTION, THE CASE OF BELL & EDISON
  GORMAN & CARLSON
  SCIENCE, TECHNOLOGY & HUMAN VALUES VOL15, No2, 90
- FROM COMPASS TO COMPUTER
  ATHERTON
  SAN FRANSISCO PRESS, 84
- BIT BY BIT, A HISTORY OF THE COMPUTER
  AUGARTEN
  UNWIN PAPERBACKS, 85
- VINTAGE TELEPHONES OF THE WORLD
  POVEY & EARL
  PETER PEREGRINUS 88
- EDISON, THE MAN WHO MADE THE FUTURE
  CLARK
  MACDONALD & JANE'S 77
- REVOLUTION IN MINIATURE
  BRAUN & MACDONALD
  CAMBRIDGE UNIVERSITY PRESS 82
- MAPLIN'S ELECTRONICS CATALOGUE
  (FOR ELECTRONIC COMPONENTS).
  MAPLINS, SOUTHEND
- PORTRAITS IN SILICON
  SLATER
  M.I.T. PRESS, 87
- HEINRICH HERTZ, THE BEGINNINGS OF MICROWAVES
  BRYANT
  INSTITUTE OF ELECTRICAL & ELECTRONIC ENGINEERS
- EARLY RADIO WAVE DETECTORS
  PHILLIPS
  PETER PEREGRINUS, 80
- SYNTONY & SPARK
  AITKEN
  PRINCETOWN UNIVERSITY PRESS, 85
- THE CONTINUOUS WAVE
  AITKEN
  PRINCETON UNIVERSITY PRESS, 85
- MAN OF HIGH FIDELITY, HOWARD ARMSTRONG
  LESSING
  BANTAM, 69
- GUGLIELMO MARCONI
  GEDDES
  THE SCIENCE MUSEUM, 74
- BROADCASTING IN BRITAIN
  GEDDES
  THE SCIENCE MUSEUM, 72
- BEHIND THE TUBE
  INGLIS
  FOCAL PRESS, 90
- MAGNETIC TAPE RECORDING
  CAMRASS
  VAN NOSTRAND, 85
- HISTORY OF TELEVISION CONFERENCE
  PUBLICATION 271
  INSTITUTE OF ELECTRICAL ENGINEERS, 88
- VIDEOCASSETTE RECORDERS
  BEECHING
  HEINEMANN NEWNES, 88
- ALMOST EVERYTHING THERE IS TO KNOW
  HUNKIN
  HAMLYN, 88
- ADVENTURES IN MICROELECTRONICS
  (BEGINNERS' ELECTRONICS KIT)
  DUNCAN
  MURRAY

PLACES TO VISIT

- THE SCIENCE MUSEUM,
  EXHIBITION RD, LONDON SW7
  071-938-8000
- NATIONAL MOTOR MUSEUM,
  BEAULIEU, HAMPSHIRE
  0590-612345
- THE CLOCK MUSEUM,
  BURY ST EDMUNDS
  0284-757072
- TELECOM SHOWCASE,
  VICTORIA ST, LONDON EC4
  071-248-7444
- WEST DULWICH RADIO MUSEUM,
  (TELEPHONE FOR APPOINTMENT)
  081-670-3667
- THE AMPEX MUSEUM,
  AMPEX, REDWOOD, CALIFORNIA
  0101-415-367-4151

I LEARN MOST ABOUT THE MACHINES BY SIMPLY TAKING THEM TO BITS WHEN THEY GO WRONG. A SURPRISING NUMBER OF FAULTS ARE VERY OBVIOUS, EVEN TO AN UNTRAINED EYE, & IT'S VERY SATISFYING IF YOU FIND THEM. EVEN IF YOU DON'T, YOU CAN STILL LEARN A LOT.

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